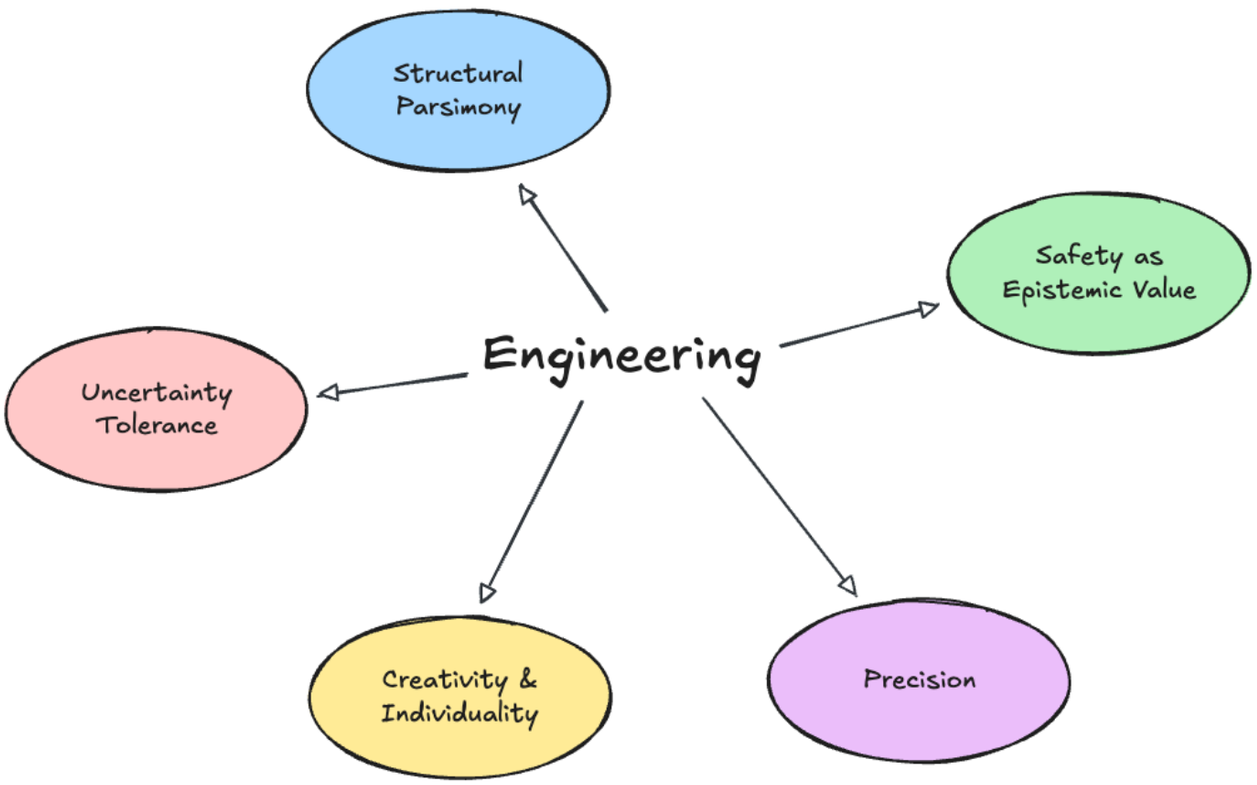
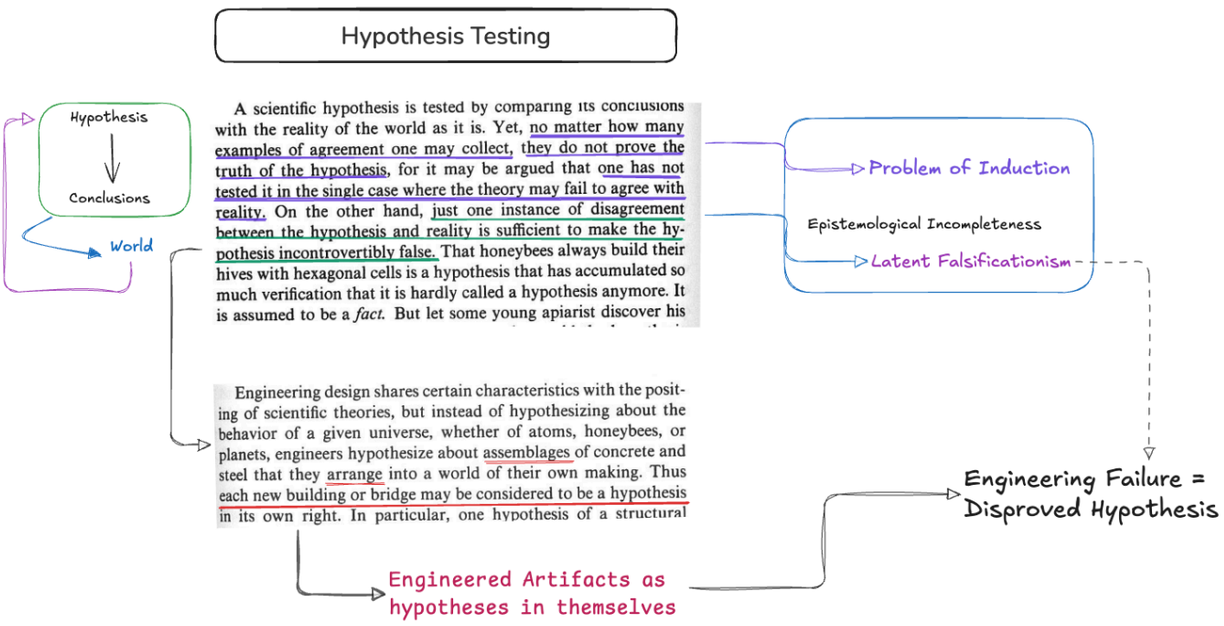
Engineering as Hypothesis - Notes

Epistemic Values of Engineering



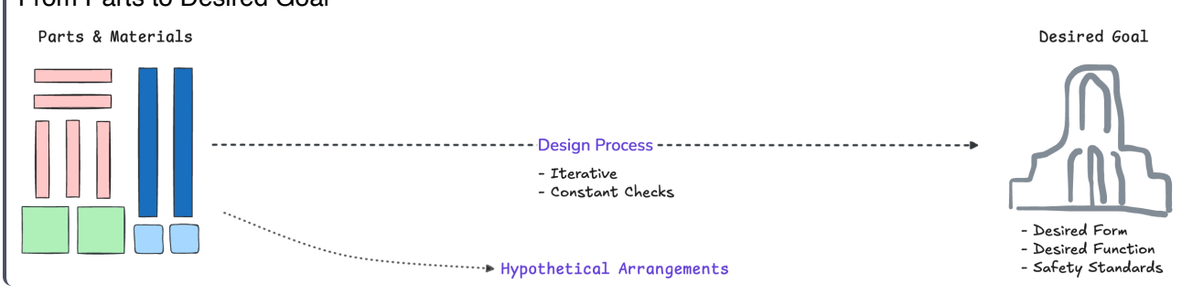
Petroski's Thesis

Engineering as Hypothesis Testing

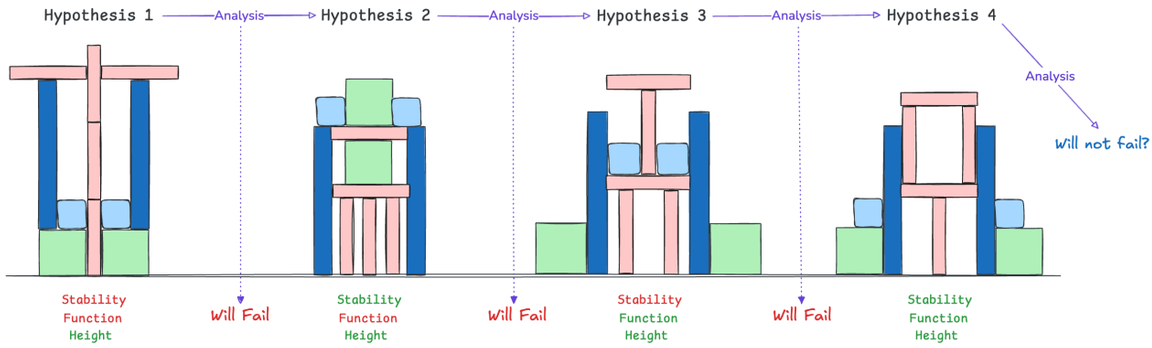

Hypothesis Testing
Hypothesis
Conclusions
World
A scientific hypothesis is tested by comparing its conclusions with the reality of the world as it is. Yet, no matter how many examples of agreement one may collect, they do not prove the truth of the hypothesis, for it may be argued that one has not tested it in the single case where the theory may fail to agree with reality. On the other hand, just one instance of disagreement between the hypothesis and reality is sufficient to make the hypothesis incontrovertibly false. That honeybees always build their hives with hexagonal cells is a hypothesis that has accumulated so much verification that it is hardly called a hypothesis anymore. It is assumed to be a fact. But let some young apiarist discover his
Problem of Induction
Epistemological Incompleteness
Latent Falsificationism
Engineering design shares certain characteristics with the positing of scientific theories, but instead of hypothesizing about the behavior of a given universe, whether of atoms, honeybees, or planets, engineers hypothesize about assemblages of concrete and steel that they arrange into a world of their own making. Thus each new building or bridge may be considered to be a hypothesis in its own right. In particular, one hypothesis of a structural
Engineering Failure = Disproved Hypothesis
Engineered Artifacts as hypotheses in themselves

Engineering Design & Hypothesis Testin

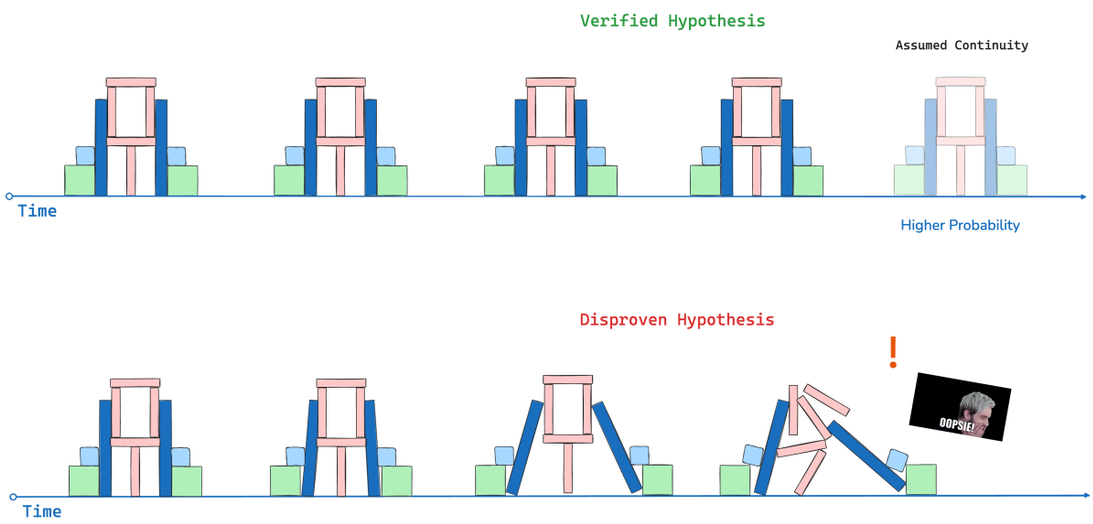
1. From Parts to Desired Goal



2. Hypothetical Arrangements



3. Verification vs Falsification of Hypothesis



Questions

Has epistemology ignored the practices of engineering and design?
Why is that?

Is the notion of hypothesis-testing in engineering too deflationary?
Is every manufactured artifact an hypothesis?

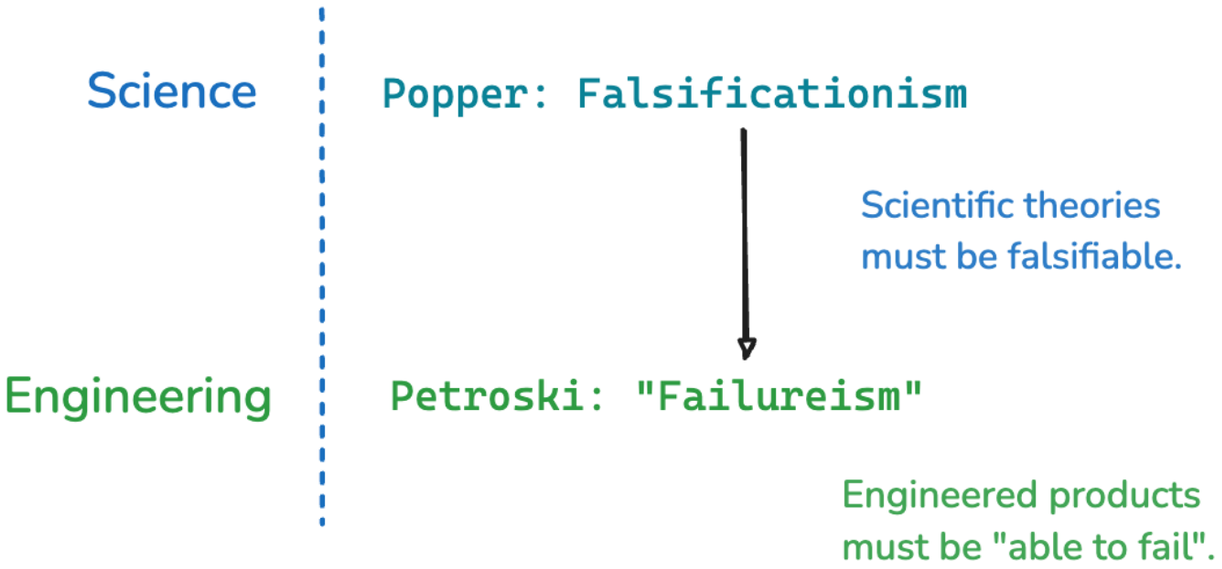
What is validating or disproving an engineering hypothesis if
it is not a designed experiment or a set of data?
What kind of validation process are we even talking about?

What is the epistemic status of failure?

Where is Explanation in Petroski's acount?

Further Thoughts & Extrapolations

Epistemology of Engineering



- Petroski's position can be seen as an extension or application of Popper's falsificationist theory to the domain of engineering where failure is the analogue to falsification and the ability to fail is analogous to falsifiability,

Functional Holism

No singular arrangment of parts in the system fails. If it does, it is analyzed and changed through the design process.

This is before its material construction which is the ultimate validity test.

-> Before-After Distinction

- An implicit assumption behind Petroski's argument of the design process as hypothesis testing is what I call "Functional Holism". This is the assumption that engineering artifacts function as consistent units where all parts are in interrelation with each other and when actually constructed in a specific place and time, they enter in interrelationships with other artifacts and the local conditions. In Petroski's words they are "man-made solar system created to be set among other man-made solar systems".

Contribution to Epistemology

Induction

Locality of Hypothesis

Uniformity of Nature → Continuity of Function

Predicates and Time

What about lawlike statement?

Norton:
all inductive inferences are material,
and have nothing formal in common

Rules?

P1. Induction only works when the predicates form lawlike generalizations.
P2. We cannot tell which predicates will form lawlike generalizations.
C. We cannot tell when induction works and when it does not.

What about very old bridges?

- I would claim that Petroski's thesis can be positioned in the historical development concerning the problem of induction. If Goodman's "riddle of induction" introduced the importance of the locality and situation-specificity of the scope of an hypothesis, then Petroski's view of engineered artifacts as hypothesis in themselves presents a further attempt at concretizing and localizing the issue of induction by moving away from universalist assumptions about inferences.
- But what is missing in Petroski's account in my opinion is a criterion for discerning between hypotheses that afford generalization and one's that don't. Goodman proposed something of that short by distinguishing propositions that look like law-like from one's that are merely circumstantial.
- The other important contribution from Petroski is to extend the discussion beyond language and formal systems and so to extend the scope of the hypothetico-deductive method to concrete material practices.

Notes

Questions

- Has epistemology ignored the practices of engineering and design? Why is that?
- Is the notion of hypothesis-testing in engineering too deflationary? Is every manufactured artifact an hypothesis?
- What is validating or disproving an engineering hypothesis if it is not a designed experiment or a set of data? What kind of validation process are we even talking about?
- What is the epistemic status of failure?

Presentation Notes

- Petrosky *is not* a philosopher of science, or at least, he is not considered as such. His style is different.

Engineering as Hypothesis

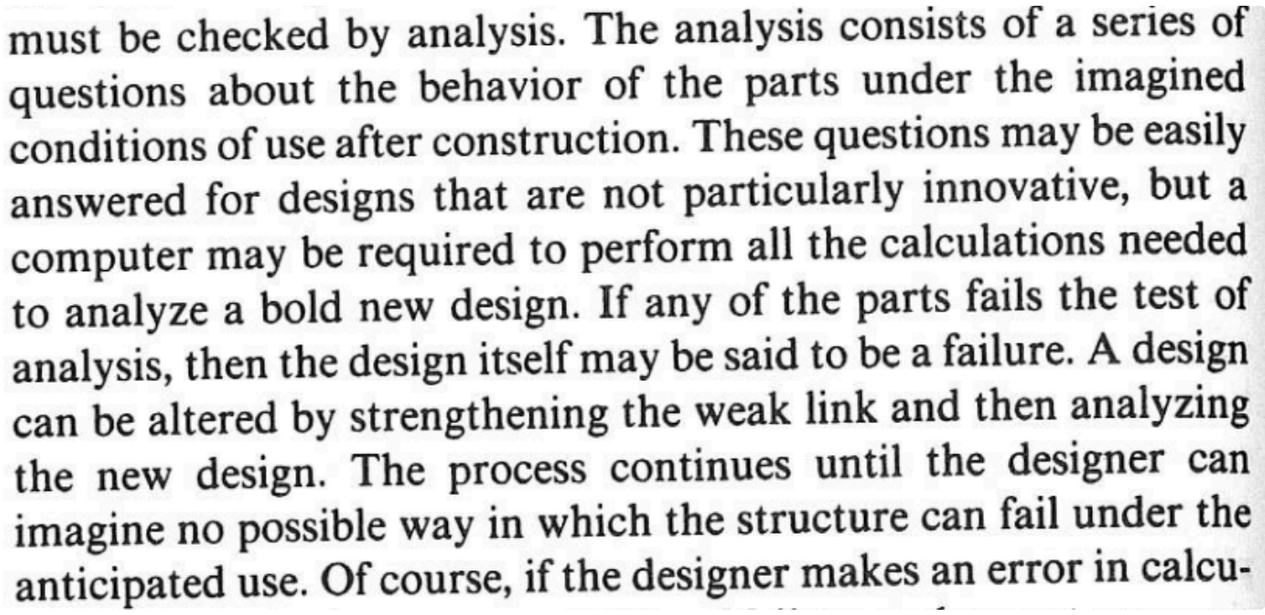
> **What is *engineering*?**
> Is it a science? Is it distinct from science? If yes, what makes it so?

Despite the answer to the question, engineering has some epistemic qualities:

1. Epistemic Valus of Engineering
    a. §3 Structural Parsimony - "Less is More" Axiom of minimalist aesthetics and design
    b. §4 Uncertainty Tolerance - Probabilities rather than Certainties - Worldy Complexity =="Man-made solar system created to be set among other man-made solar systems"
    c. §5 Safety as an epistemic value
    d. §6 From Subjectivity & Individuality to Hypothesis Testing - Cook-off : Process of increasing precision and clarity
2. Hypothesis Testing as Foundation
    a. Popperian Falsificationist Approach of Petrosky
    b. The target of hypothesis - materials
    c. "Every building or bridge can be considered an hypothesis in its own right"
    d. The continuous successful functioning (non-failing) of a bridge in time is the **confirmation of the hypothesis**. But it can never be *proven* - if the bridge suddenly collapses, the hypothesis will be proven wrong.
        i. -> Induction but closer to Goodman -> specific uniformity assumption for every engineered artifact
        ii. It is possible to go even further in an attempt to dismantle the Humean circularity. Maybe inductive inferences do not even have a rule in common. What if every inductive inference is essentially unique? This can be seen as rejecting Hume's premise P5. Okasha, for example, argues that Hume's circularity problem can be evaded if there are "no rules" behind induction (Okasha 2005a,b). Norton puts forward the similar idea that all inductive inferences are material, and have nothing formal in common (Norton 2003, 2010, 2021).
        iii. Claim: The engineering hypothesis is different from Goodman's riddle because it doesn't rely on the inductive schema: {x IS y ^ x IS y ^ x IS y... all observed x are y -> "All x are y"}. It's a negative schema: {x hasn't failed until time tn}. The uniformity assumption here is that because this specific x hasn't failed
        a) it's underlying material design choices hold and
        b) it will keep on not-failing.

            > Is there a lawfulness behind this?

        iv. Material induction: The ce here is that we are not dealing with statement and predicates. We are not even dealing with propositional language. We are dealing with material artifacts that are externalized.



must be checked by analysis. The analysis consists of a series of questions about the behavior of the parts under the imagined conditions of use after construction. These questions may be easily answered for designs that are not particularly innovative, but a computer may be required to perform all the calculations needed to analyze a bold new design. If any of the parts fails the test of analysis, then the design itself may be said to be a failure. A design can be altered by strengthening the weak link and then analyzing the new design. The process continues until the designer can imagine no possible way in which the structure can fail under the anticipated use. Of course, if the designer makes an error in calcu-

4. **Functional Holism** - > No singular arrangment of parts in the system fails. If it does, it is analyzed and changed through the **design process**. This is before the material construction which is the ultimate test -> Different that scientific method, where the process of hypothesis generation and testing are different - No need for the hypothesis generation to be clearly publisized in propositional language.

   > Desired Function, Goal, Anticipated Use -> Determinant criterion for assesing validity -> From Falsification to Failure
   >
   > Demarcation:
   >
   > Pseudoscience: Scientific theories (hypotheses, models, methods) must be falsifiable.
   >
   > -> Pseudoengineering demarcation: Engineered products must be *able to fail*.

Failure-ism

Engineering has a more "failure-adverse culture" to theoretical counterparts

> *Wired* magazine editor Kevin Kelly explains that a great deal can be learned from things going wrong unexpectedly, and that part of science's success comes from keeping blunders **"small, manageable, constant, and trackable"**. He uses the example of engineers and programmers who push systems to their limits, breaking them to learn about them. Kelly also warns against creating a culture that punishes failure harshly, because this inhibits a creative process, and risks teaching people not to communicate important failures with others (e.g., null results).14(https://en.wikipedia.org/wiki/Failure#cite_note-14) Failure can also be used productively, for instance to find identify ambiguous cases that warrant further interpretation.15(https://en.wikipedia.org/wiki/Failure#cite_note-15)[[16]] (https://en.wikipedia.org/wiki/Failure#cite_note-16) When studying biases in machine learning, for instance, failure can be seen as a "*cybernetic rupture* where pre-existing biases and structural flaws make themselves known".17(https://en.wikipedia.org/wiki/Failure#cite_note-17)